NEW SILURIAN GRAPTOLITES FROM THE HOWGILL FELLS (NORTHERN ENGLAND)

by R. B. RICKARDS

Abstract. Recent work on the graptolite faunas of the Silurian strata of north-west Yorkshire and Westmorland has unearthed, from the Wenlock and Ludlow Series, species previously recorded from the Continent, and in addition several new species and subspecies. The following new forms are described: *Monoclimacis griestonensis nicoli* subsp. nov., *M. shottoni* sp. nov., *M. flumendosae kingi* subsp. nov., *Pristiograptus watneyae* sp. nov., *P. welchae* sp. nov., *P. dubius pseudolatus* subsp. nov., *P. auctus* sp. nov., *Monograptus firmus sedberghensis* subsp. nov., *M. radotinensis inclinatus* subsp. nov., *M. minimus cautleyensis* subsp. nov., *M. danbyi* sp. nov., *M. simulatus* sp. nov.

The nineteen graptolites described in this paper form part of a large graptolite fauna obtained from the Wenlock and Ludlow Series during a revision of the Silurian stratigraphy of the Howgill Fells. Text-fig. 1 gives the ranges of the described species against the zones recognized in the region, and the correlation of these zones with those established by Elles (1900) and Wood (1900) in the Welsh Borders.

Eight of the described forms have previously been recorded only from the continental countries where they are found at similar horizons. *Monoclimacis flumendosae* (Gortani) occurs earlier in the Howgill Fells than in Czechoslovakia, where it first appears in the *rigidus* Zone, but in both areas it ranges into the higher Wenlock strata. However, whilst the species remains unchanged throughout its range in Czechoslovakia, the typical form is replaced by the subspecies *flumendosae kingi* in the *lundgreni* Zone of the Howgill Fells.

Monograptus minimus cautleyensis and *M. firmus sedberghensis* occur at approximately the same horizons as the type subspecies in Czechoslovakia and may represent genuine cases of geographical subspeciation. *M. minimus* s.s. and *M. firmus* s.s. have not been recorded from the British Silurian.

Monograptus radotinensis inclinatus is best regarded as a chronological subspecies since it is found in the zone above that from which Bouček's *radotinensis* s.s. was recorded in Czechoslovakia.

Monoclimacis? haupti has previously been recorded only from erratic boulders (Kühne 1955, Germany; Urbanek 1958, Poland) where it is associated with a *nilssoni-scanicus* Zone fauna. The associated *nilssoni-scanicus* fauna in the Howgill, Barbon, and Middleton Fells of northern England confirms the horizon given by the above authors.

Monoclimacis griestonensis nicoli and *Pristiograptus dubius pseudolatus* have probably evolved from their respective type subspecies and reflect a tendency to increased robustness of the rhabdosome in some monoclimacids and pristiograptids.

The new species described also have considerable significance particularly as regards local stratigraphy. *Monograptus danbyi*, *M. shottoni*, and their associates, for example, allow a correlation, not only throughout the Cautley district of the Howgill Fells, but with the Cross Fell area to the north east of the main Lake District Silurian outcrop. This association comprises the *centrifugus* Zone assemblage.

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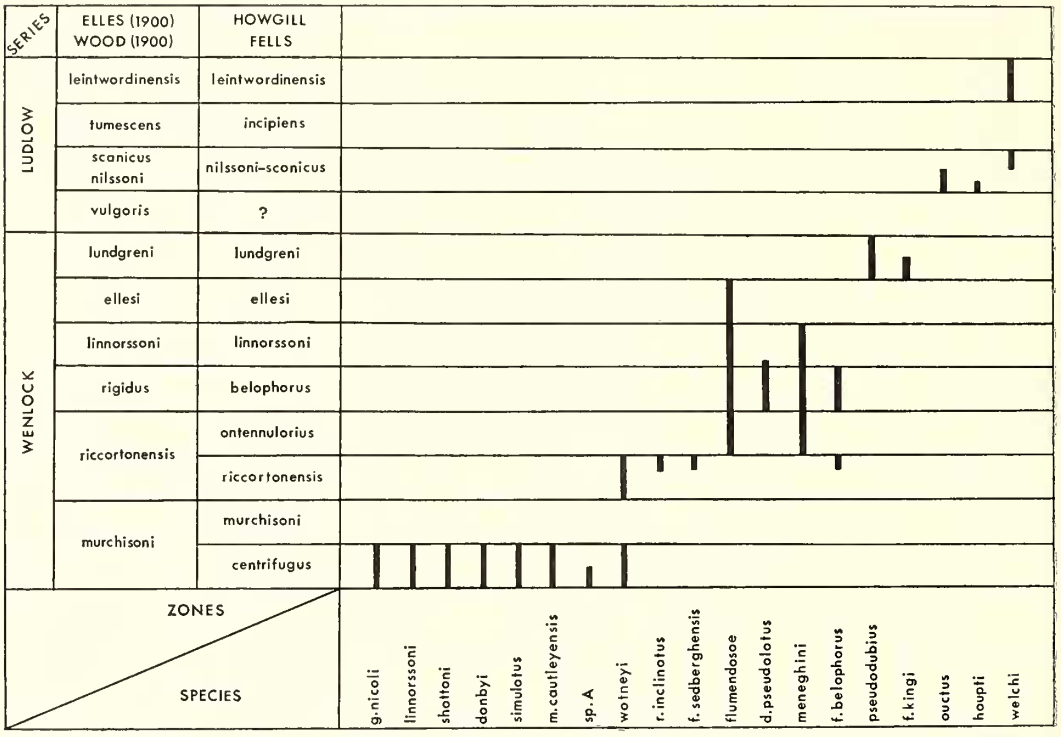
In the systematic descriptions below distinction is always made between specimens preserved in relief and flattened specimens. The term 'flattened' is used to describe specimens which have been reduced by diagenetic processes to a filmy deposit on the bedding plane, whilst the term 'compressed' is used to describe rhabdosomes (either flattened or in relief) which have suffered tectonic deformation. Crustal shortening can



TEXT-FIG. 1. Ranges of the species described, plotted against the zones recognized in the Howgill Fells; and the correlation of these zones with those established in the Welsh Borders. The Wenlock Zones of Elles (1900) and the Ludlow Zones of Wood (1900) are shown in one column. For *watneyi* and *welchi* read *watneyae* and *welchae* respectively.

usually be detected by the presence on the bedding planes of distinct lineations, which are, in fact, minute folds.

Several morphological terms used in the descriptions below require definition:

Width is the total rhabdosomal width inclusive of thecal hooks; *length of thecal tube* is measured along a line midway between the ventral and dorsal walls, as seen in profile view; *thecal spacing* is measured for a small number of thecae (1–3), and is then translated to 'thecae per cm.', since it is considered that this gives a better idea of the change in cell size along the rhabdosome. Packham (1962) seems to have used a similar technique.

The Howgill Fells form a most distinct topographical feature of high, rounded hills extending from north-west Yorkshire into Westmorland, and may be contrasted with the Carboniferous country to the east and north. They occupy a broadly triangular area with the town of Sedbergh at the southern apex. Tebay forms the north-west limit of the

fells and Ravenstonedale village the north-east. The village of Cautley, from the vicinity of which many of the graptolites were obtained, is situated between Sedbergh and Ravenstonedale on the eastern flanks of the fells. The area is covered by the following Ordnance Survey 6″ sheets: SD69 NW, NE, SW, SE; SD79 NW, SW; NY60 NE, NW, SW, SE; NY70 SW.

The appendix gives four-figure grid references to all the localities mentioned in the systematic descriptions. All the type specimens are deposited in the Department of Geology, Hull University. Abbreviations associated with catalogue numbers are as follows: B.U. Birmingham University; HUR. Hull University Rickards' Collection.

Acknowledgements. I should particularly like to thank Dr. J. W. Neale and Dr. I. Strachan for their many helpful suggestions and whole-hearted support at all stages of this work.

SYSTEMATIC DESCRIPTIONS

Class GRAPTOLITHINA Bronn 1846
Order GRAPTOLOIDEA Lapworth 1875
Suborder MONOGRAPTINA Lapworth 1880
Family MONOGRAPTIDAE Lapworth 1875
Genus MONOCLIMACIS Frech 1897

Type species. Graptolites vomerinus Nicholson 1872, emend. Lapworth.

Diagnosis. Rhabdosome often long and more or less straight, though slight curvature common proximally and rarer distally; ventral wall of each theca subsequent to th. 1, usually with distinct excavation; the infragenicular wall overhangs the apertural region of the preceding theca; apertural region often appears to be 'hooked', but in some representatives, at least, this is a monofusellar structure growing from the geniculum of the succeeding theca.

Monoclimacis griestonensis nicoli subsp. nov.

Plate 30, fig. 4

Holotype. HUR./8P/19, a proximal fragment in full relief with sicula preserved.

Other material. Five specimens preserved in relief.

Horizon and localities. Zone of *C. centrifugus*, Wenlock Series; Pickering Gill (8P), near Cautley.

Derivation of name. After J. Nicol, author of *M. griestonensis.*

Diagnosis. Rhabdosome known from fragments only, but probably quite short. Maximum breadth 0·3 mm. Thecae long, narrow tubes closely adpressed to the axis, numbering 9–9½ in 10 mm.

Description. The subspecies is known only from short fragments, up to 1 cm. long, which do not exceed 0·3 mm. in width. This width is achieved at a distance of 5 mm. from the base of the sicula and thereafter the rhabdosome is parallel-sided.

The sicula is prominent, 1·5 mm. long, and its apex reaches almost to the level of the aperture of th. 1. The sicular aperture measures 0·2 mm. across and is furnished with a short, slim virgella. Th. 1 arises 0·4 mm. above the base of the sicula and is 1·17 mm. long.

Thecal overlap is approximately one quarter. Each thecal tube grows almost parallel to the axis for a distance of 0·5 mm. and then takes a slight bend towards the ventral side which results in a shallow excavation. The thecae then grow once again at a low angle of inclination.

Remarks. The diagnostic features considered above fall within the ranges of variation given by Elles and Wood (1910) for *griestonensis* s.s. However, the specimen figured by these authoresses as text-fig. 279*a* (B.U. 1556) has the thecae more closely spaced (13 in 10 mm.) than is indicated by their description; and their fig. 6*a*, plate 41, which occurs on Nicol's type slab, has 12–14 thecae per centimetre. (The only other fossils on the type slab are two of *Monograptus spiralis* s.l. and another very poor specimen of *M. griestonensis*.) Other specimens from the type locality of Grieston Quarry examined by the writer also show a close spacing of the thecae in proximal region. *M. griestonensis nicoli* differs, therefore, from the type subspecies in having its thecae more widely spaced. In addition the rhabdosome is initially more robust and the excavation of the ventral margin of the thecal wall is less. The sicula in *nicoli* is very prominent and almost twice the size of that in *griestonensis* s.s.

M. g. nicoli has a similar thecal spacing to *M. g. kettneri* Bouček 1931*b*, and *M. g. minuta* Přibyl 1940*a*, and a rhabdosomal width akin to the latter. From both subspecies *nicoli* differs, however, in its relatively robust initial portion, large sicula, and less conspicuous excavation. *M. g. nicoli* also differs from *kettneri* in its lack of dorsal curvature in the proximal region.

Monoclimacis linnarssoni (Tullberg)

Plate 30, fig. 5; text-fig. 2*a*, *b*

1883 *Monograptus linnarssoni* Tullberg, p. 20, pl. 2, figs. 5–9.

Material. A single distal fragment in low relief, some 5½ cm. long; two proximal ends in full relief with sicula preserved, and five other fragments.

Horizon and localities. Zone of *C. centrifugus*; Middle Gill (4M), Pickering Gill (10P), Cautley.

Description. The distal fragment of the rhabdosome is quite straight and fully 5½ cm. long. At the most proximal point seen the rhabdosomal width is 0·91 mm. The rhabdosome is almost parallel-sided and at the distal extremity is still only 1·17 mm. wide.

The thecae are sigmoidally curved tubes inclined to the axis at a low angle (approxi-

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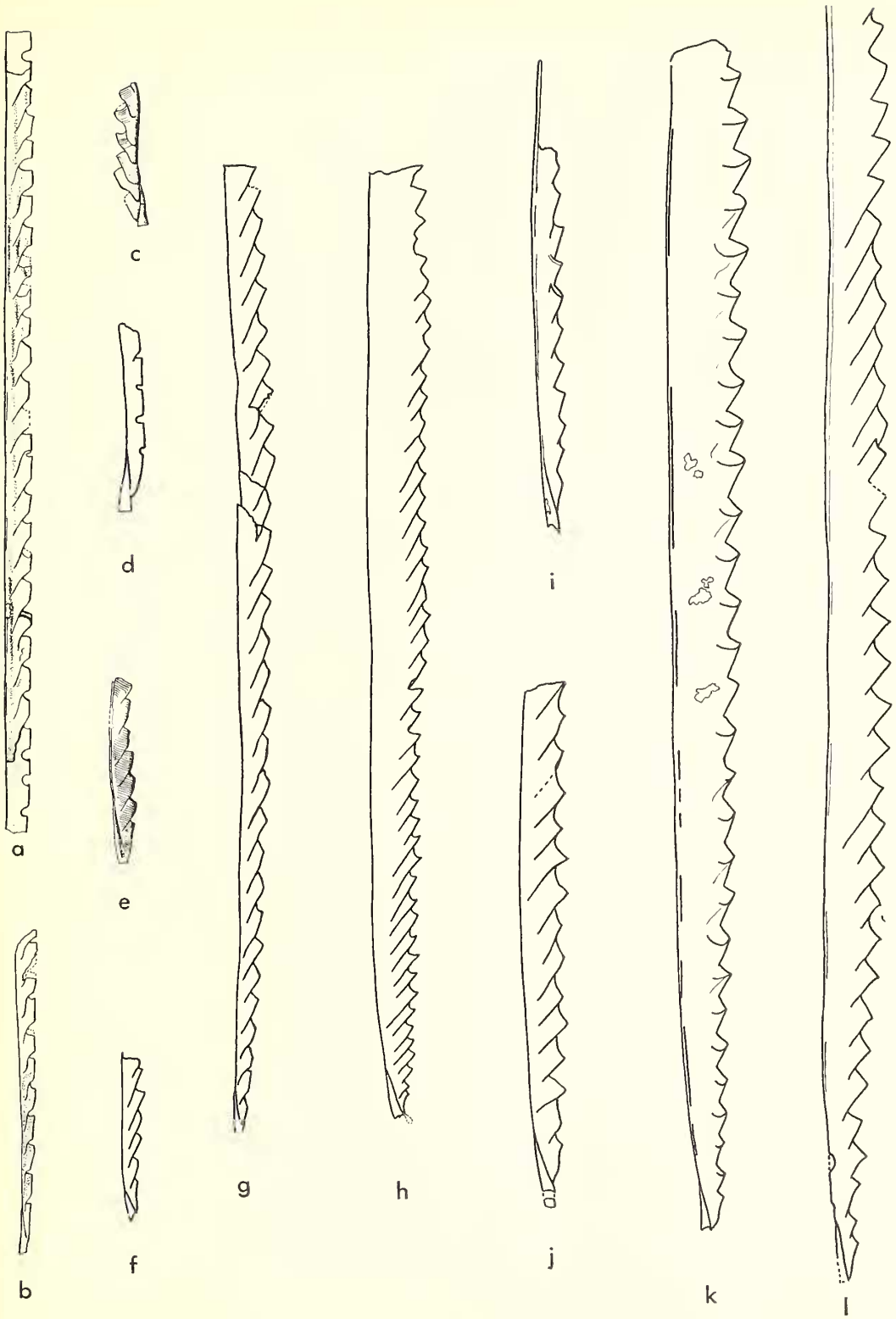
TEXT-FIG. 2. *a*, *Monoclimacis linnarssoni* (Tullberg), HUR./4M/72, long distal fragment in low relief, *centrifugus* Zone. *b*, *M. linnarssoni* (Tullberg), HUR./10P/41, proximal end in relief with sicula preserved, *centrifugus* Zone. *c*, *M? haupti* (Kühne), HUR./2W/35, slightly distorted specimen in full relief, *nilssoni-scanicus* Zone. *d*, *M. f. flumendosae* (Gortani), HUR./17N/232, flattened proximal end with rather short sicula, *linnarssoni* Zone. *e*, *M. shottoni* sp. nov., holotype, HUR./28W/76, complete specimen in relief, *centrifugus* Zone. *f*, *Pristiograptus welchae* sp. nov. holotype, HUR./1Ab/22, complete but flattened specimen, *leintwardinensis* Zone. *g*, *P. watneyae* sp. nov., holotype, HUR./37W/17, proximal part of a long specimen in full relief, *centrifugus* Zone. *h*, *P. auctus* sp. nov., holotype, HUR./7W/46, expanded virgella only poorly preserved, *nilssoni-scanicus* Zone. *i*, *P. pseudodubius* (Bouček), HUR./26N/11, *lundgreni* Zone. *j*, *P. meneghini* (Gortani) HUR./17N/46, *linnarssoni* Zone. *k*, *P. dubius pseudolatus* sp. nov., holotype, HUR./18N/53a, long flattened specimen, *belophorus* Zone. *l*, *P. d. dubius* (Suess), HUR./18N/6, flattened specimen, *belophorus* Zone. All figures ×5.



TEXT-FIG. 2.

mately 20°), and number 9 in 10 mm. throughout the whole $5\frac{1}{2}$ cm. Excavations of the ventral margin of each theca are conspicuous and deep, occupying almost half the width of the rhabdosome. The length of the excavation is 0·4 mm.

The proximal ends have thecae whose general characters are identical to those shown on the distal fragment, but they are smaller and number 10 in 10 mm. The sicula is long and slender, measuring slightly over 2 mm., and has its apex situated midway between the apertures of th. 1 and th. 2.

Remarks. The thecal characters distinguish this rare species from all others occurring at Cautley. It closely resembles Tullberg's original figures, particularly in the size and position of the sicula; the only difference is that the Cautley specimens have slightly longer thecal excavations. Tullberg (1883, p. 20) gives a thecal count of 7–8 in 10 mm. but Přibyl (1940*a*) gives a range of 10–8 in 10 mm. Přibyl, however, includes Elles and Wood's *Monograptus* cf. *griestonensis* in his synonymy of *linnarssoni*. This in the writer's opinion is a dubious step since the former shows major differences from *linnarssoni* particularly as regards thecal spacing. *M.* cf. *griestonensis* has a thecal spacing of 9–12 in 10 mm. and a sicula, only 1·5 mm. long, whose apex is midway between the apertures of th. 1 and th. 2. Furthermore, *M.* cf. *griestonensis* has 'hooked' apertures to the first few thecae. This does not seem to be the case with *M. linnarssoni* Tullberg.

Monoclimacis flumendosae flumendosae Gortani

Plate 29, figs. 1–3; text-figs. 2*d*, 4*f*

?1911 *Monograptus vomerinus* var. *β* Elles; Watney and Welch, text and tables (pars).
1922 *Monograptus linnarssoni* v. *flumendosae* Gortani.
1931*a* *Monograptus lejskoviensis* Bouček, pp. 9–10, text-fig. 3*a–c*.
1940*a* *Monoclimacis flumendosae* (Gortani 1922); Přibyl, p. 6, pl. 2, figs. 14–16.

Material. Several hundred specimens, all flattened, many well preserved.

Horizons and localities. Zone of *Monograptus antennularius* to Zone of *Cyrtograptus ellesi*; Middle Gill (16M, 18M, 19M, 20M, 23M, 26M, 27M, 28M, 29M, 30M), Near Gill (16N–23N), Wandale Hill (43–46W), R. Rawthey (9–11Ra), mouth of Wandale Beck (67–69W).

Diagnosis. Full length unknown but probably greater than 30 cm.; distal width 2 mm. (flattened), initial width 0·3 to 0·5 mm.; slight, but characteristic, dorso-ventral curvature; thecae number 8–10 in 10 mm.

Description. The rhabdosome has a very characteristic appearance, widening from a slender and graceful proximal end, which almost invariably shows distinct dorsal

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DESCRIPTION OF PLATE 29

Figs. 1–3, *Monoclimacis flumendosae flumendosae* (Gortani), *linnarssoni* Zone. 1, HUR./17N/244, well-preserved specimen showing characteristic double curvature. 2, HUR./17N/216, distal part of rhabdosome. 3, HUR./17N/232, proximal end with sicula. Figs. 4–6, *Monograptus simulatus* sp. nov., *centrifugus* Zone. 4, HUR./4M/62, two thecae showing thecal hook, × 10. 5, HUR./4M/62, paratype. 6, Holotype, HUR/28W/25, specimen in relief. Fig. 7, *Pristiograptus meneghini* (Gortani), HUR./17N/46, *linnarssoni* Zone. Figs. 8–9, *Monograptus flexilis belophorus*, respectively HUR./13M/74 and HUR./16M/20, *riccartonensis* and *belophorus* Zones, proximal and distal regions, flattened, showing typical curvature. Fig. 10, *Pristiograptus pseudodubius* (Bouček), HUR./26N/11, flattened specimen with sicula and nema, *hudgreni* Zone. All figs. × 5 except where otherwise stated, unretouched.


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curvature (Pl. 29, figs. 1, 3) to a long and variously curved distal region. Whilst many specimens are almost straight distally, equally as many show a gentle ventral or dorsal flexure.

For the first 3–5 mm. the proximal end is sharply recurved and the sicula is prominent. Specimens in relief must be very slender and graceful in this region.

The sicula is 2 mm. long and its apex is above the level of the aperture of th. 1. Occasional specimens show a slightly shorter sicula whose apparent apex barely reaches the level of the aperture of th. 1; but in these specimens the true apex may be hidden. The sicula is rarely curved.

Th. 1 originates fully 0·4 mm. above the base of the sicula which is, therefore, conspicuous with its short virgella. At the proximal end the thecal spacing is very constant at 10 thecae in 10 mm. The change distally is gradual and even the most distal fragments obtained do not show less than 8 thecae in 10 mm.

Thecal excavation is well marked throughout the rhabdosome but distally it increases in length. As a rule it occupies about one-third the total width of the rhabdosome. The excavation is, however, rather less prominent than in some earlier monoclimacids. The distal thecae occasionally show a pristioform view akin to that sometimes seen in distal thecae of *Monoclimacis vomerina basilica* (Lapworth 1880).

Remarks. M. f. flumendosae differs from the subspecies *M. f. kingi* subsp. nov. (described below) in being more robust throughout the length of the rhabdosome and in the less closely spaced proximal thecae. Otherwise the two are very closely allied, and *kingi*, found in the *lundgreni* Zone, evolved from the type subspecies which is common in the pre-*lundgreni* zones of *antennularius* to *ellesi*.

The only other form with which *M. f. flumendosae* might be confused is *M. vomerina basilica*. The latter form is, however, much broader distally and lacks the curvature and large sicula typical of the proximal end of *flumendosae*.

The Cautley specimens agree closely with those described and figured by Gortani (1922) as *Monograptus linnarssoni* var. *flumendosae* from the Silurian of Sardinia, and with Bouček's (1931*a*) *Monograptus lejskoviensis* from Czechoslovakia. Přibyl (1940*a*) rightly regards *flumendosae* and *lejskoviensis* as the same species. The only difference between the writer's material and that described by the above authors is that *flumendosae* from the Cautley district has a more slender proximal end, which is 0·3 to 0·5 mm. wide at the level of th. 1, and may be contrasted with the figure of 0·6 mm. given by Přibyl (1940*a*).

M. f. flumendosae has not previously been recorded from the Cautley area but it is possible that the form described by Watney and Welch (1911) as *Monograptus vomerinus* var. β (= *gracilis*; Elles and Wood 1910, p. 44) should, in part at least, be referred to *M. flumendosae*. *M. vomerina gracilis* (Elles and Wood) has not been found by the present writer from the Silurian of Cautley.

Monoclimacis flumendosae kingi subsp. nov.

Text-fig. 4*e*

Holotype. HUR./28N/4, a proximal end with sicula, flattened.

Other material. About thirty specimens, all flattened but well preserved.

Horizon and localities. Lower half of the *lundgreni* Zone, Wenlock Series; Near Gill (25N–29N), Crosshaw Beck (1Cr, 2Cr); Cautley, near Sedbergh.

Derivation of name. In honour of the late Professor W. B. R. King, contributor for many years to the problems of Lower Palaeozoic stratigraphy.

Diagnosis. Rhabdosome similar to type subspecies but more slender throughout; initial width 0·3 mm., distally less than 2 mm.; thecal spacing 11–8 in 10 mm.

Description. The whole general form of the rhabdosome is very close to that of the type subspecies (described above) but is invariably more slender throughout its whole length. At the level of th. 1 the rhabdosomal width (flattened) is 0·3 mm.

The thecae are more closely spaced and counts of 11 in 10 mm. are typical over the first few centimetres. Thereafter the thecae become gradually larger and the count falls to 10 and 9 in 10 mm. Extreme distal fragments, which are less than 2 mm. in width, have a thecal spacing of as low as 8 in 10 mm.

Monoclimacis shottoni sp. nov.

Plate 30, fig. 3; text-fig. 2*e*

?1900 *Monograptus vomerinus* var. γ Elles, p. 405, text-fig. 17.
1935 *Monograptus vomerinus* var. *crenulatus* (Törnquist); Shotton, p. 661.

Holotype. HUR./28W/76 a complete specimen in full relief.

Material. Numerous specimens in full relief, all well preserved.

Horizon and localities. Zone of *C. centrifugus*; Wandale Hill (28W), mouth of Wandale Beck (49W, 51W), Pickering Gill (3P, 5P, 6P, 10P), River Rawthey (8Ra); Cautley, near Sedbergh; Cross Fell.

Derivation of name. In honour of Professor F. W. Shotton.

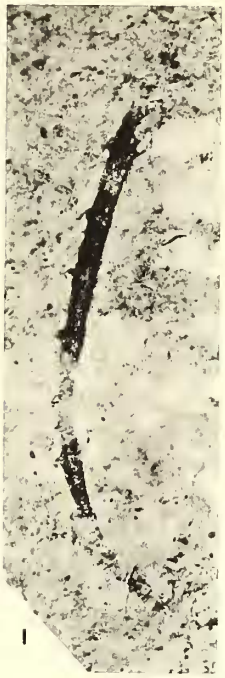
Diagnosis. Rhabdosome short, with slight ventral curvature, narrowing distally; sicula prominent; thecae with distinct sigmoidal curvature numbering 12–13 in 10 mm.

Description. No specimens over 7 mm. long have been obtained and since these narrow towards their distal extremities it is thought that they are full grown. The maximum width is reached at th. 4 and rarely exceeds 0·71 mm. At th. 7 the width has decreased to 0·58 mm.

The sicula is 2 mm. long and its apex invariably reaches the level of the second thecal aperture. It is 0·29 mm. wide at the base and shows a faint ventral curvature. Th. 1 arises 0·20 mm. above the sicular aperture. Thecal lengths are as follows: th. 1, 0·9 mm.; th. 2, 0·9 mm.; th. 3, 1·17 mm.; th. 4, 1·23 mm.; th. 5, 1·3 mm.

DESCRIPTION OF PLATE 30

Fig. 1, *Monograptus* aff *mininus cantleyensis* subsp. nov., HUR./1M/116, specimen in relief with thecal hooks apparently less enrolled, *centrifugus* Zone. Fig. 2, *Monograptus danbyi* sp. nov., holotype, HUR./8P/1, specimen in full relief with sicula, *centrifugus* Zone. Fig. 3, *Monoclimacis shottoni* sp. nov., holotype, HUR./28W/76, complete specimen in relief, *centrifugus* Zone. Fig. 4, *M. griestonensis nicoli* subsp. nov., holotype, HUR./8P/19, specimen in relief, *centrifugus* Zone. Fig. 5, *M. linnarssoni* (Tullberg), HUR./10P/47, *centrifugus* Zone. Fig. 6, *Pristiograptus welchae* sp. nov., holotype, HUR./1Ab/22, flattened specimen, *leintwardinensis* Zone. Figs. 7–8, *P. watneyae* sp. nov., distal and proximal parts of holotype, HUR./37W/17, specimen in relief, *centrifugus* Zone. All figs. × 10, unretouched.



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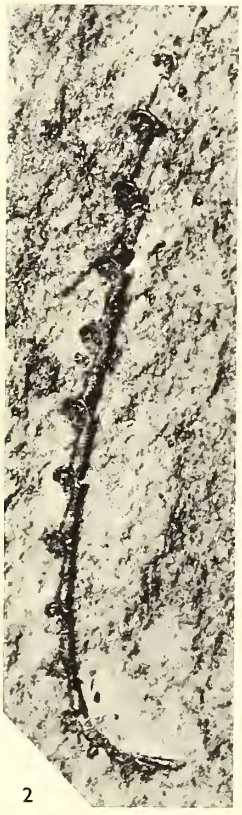

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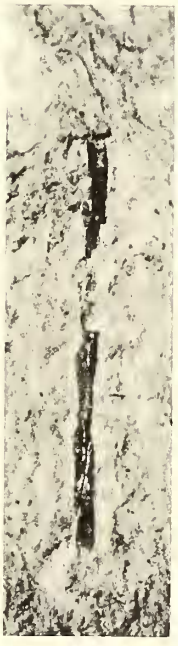

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RICKARDS, Silurian graptolites

Growth-lines are usually visible on the thecae but not always on the sicula. As in the case of *M. haupti* (Kühne) described below, there is an increase in width of the growth-bands from the proximal to the distal thecae. In *M. shottoni* there are over twenty growth-bands in th. 1 (7–8 in the metathecal portion) but each succeeding theca has only 14–15 such bands (6–7 in the metathecal portion). There is no diminution in width of the bands in the distal region where the rhabdosome begins to narrow (th. 5–7).

The apertural margins of the thecae are not 'hooked' but appear to be slightly everted. The ventral excavation of the thecal tube is pronounced.

Remarks. M. shottoni closely resembles those specimens figured by Elles (1900) as *M. vomerinus* var. γ and included by Elles and Wood (1910) in their synonomy of *M. crenulatus* Törnquist. These, which are figured natural size, are rather broader than the Cautley specimens, however, but have the same size sicula (2 mm.), the same thecal count (12–13 thecae in 10 mm.), similar general size, and are recorded from the *murchisoni* Zone. (Reference to their table 10, p. 406, suggests that the figure may be more than natural size.) No other figured specimens of *M. crenulata* (Törnquist) resembles the Cautley material.

M. shottoni was first recorded by Professor Shotton (1935) from his locality 'g', Swindale Beck, as *M. vomerinus* var. *crenulatus* (Törnquist). Some of these specimens are now contained in the Sedgwick Museum, Cambridge, and are identical with the Cautley form.

Monoclimacis? haupti (Kühne)

Text-fig. 2*c*

1955 *Monograptus haupti* Kühne, pp. 365–8, fig. 3A–F.
1958 *Monoclimacis haupti* (Kühne); Urbanek, pp. 89–92, text-figs. 59–65, pl. 4, fig. 5.

Holotype. Specimen figured by Kühne (1955) fig. 3A–F.

Material. A single specimen from the Howgill Fells, north of Sedbergh, and other less well-preserved specimens from the Barbon Fells, south of Sedbergh.

Horizon and localities. Near the base of the *nilssoni-scanicus* Zone, Ludlow Series; Wandale Hill (2W), Barbon Fells.

Diagnosis. Rhabdosome short, almost straight, sicula conspicuous and ventrally curved; thecae with distinct sigmoidal curvature numbering 12–14 in 10 mm.

Description. The sicula has a minimum length of 1·43 mm. Its apex is hidden in the specimens seen but probably extends to the level of the second thecal aperture. In spite of the fact that the best specimen has been displaced at the level of th. 3 (giving an apparent dorsal curvature) the sicula is clearly curved ventrally. Three distinct rings are present on the upper half of the sicula, which are thought to be equivalent to the 'peridermal rings' described by Urbanek (1958, p. 58). At the base the sicula is 0·32 mm. across, and between this point and the lowest peridermal ring there are about thirty-five growth bands. This figure agrees closely with Urbanek's fig. 61*c* (1958, p. 90). The middle peridermal ring is 0·26 mm. above the lower, and the top one 0·13 mm. above the middle.

Th. 1 originates 0·1 mm. above the base of the sicula and has a length of 0·7 mm. Succeeding thecae increase slowly in length up to th. 5 (the last measurable theca on the

specimens available) which is 1·3 mm. long. At this point the width of the rhabdosome is 0·71 mm.

Each prothecal portion has approximately 14–15 growth-bands (counted in profile view) and the metathecae 8–9 bands. There is a distinct and gradual increase in the width of the growth-bands (measured in a sense parallel to the length of the rhabdosome) from the sicula, where they are narrow, to th. 5 where they are 0·50 mm. wide.

Remarks. Urbanek (1958) considers that Kühne's species is in fact a monoclimacid in view of the strong sigmoidal curvature of the thecae. Furthermore, he suggested (p. 90) that *M. haupti* may be conspecific with *Monograptus praeultimus* Münch 1942. *M. praeultimus* has a thecal spacing of 12–14 in 10 mm. Its maximum width is 1·1 mm. *M. ultimus* Perner 1899 is also considered by Urbanek to be referable to the genus *Monoclimacis* Frech.

The specimens described by Kühne (1955) and Urbanek (1958) were obtained from erratic boulders.

Genus PRISTIOGRAPTUS Jaekel 1889

Type species. P. frequens Jaekel 1889.

Diagnosis. Rhabdosome of very variable length and curvature but commonly almost straight; thecae are straight, simple tubes throughout length of rhabdosome, and have varying degrees of overlap and inclination; sicula small to very large.

Pristiograptus watneyae sp. nov.

Plate 30, figs. 7, 8; text-fig. 2*g*

?1900 *Monograptus hisingeri* Carr. var., Elles, tables.
?1911 *Monograptus hisingeri* Carr. var., Watney and Welch, p. 219 and tables (pars.).

Holotype. HUR./37W/19 and counterpart /17, specimen in full relief with a length of 14 cm.

Horizon of holotype. Zone of *C. centrifugus.*

Derivation of name. After Miss G. R. Watney, joint author, with Miss E. G. Welch (1911), of a valuable paper on the Salopian stratigraphy of the Cautley area.

Material. Two well-preserved specimens, the holotype and a mesial fragment, and other doubtful specimens.

Horizon and localities. Zones of *C. centrifugus* and *M. riccartonensis,* doubtful above the latter; Wandale Hill (37W), Hobdale Beck (1Hd).

Diagnosis. Rhabdosome long and straight, distally 2·3 mm. wide; thecae simple overlapping tubes numbering 7–13 in 10 mm.; angle of inclination a maximum of 40°.

Description. (Drawn mainly from the holotype.) The rhabdosome is long and mostly straight but with a very slight dorsal curvature at the proximal end, the whole being very similar to *P. regularis* (Törnquist 1899).

The sicula has a length of 1·43 mm. and is quite inconspicuous. Its apex reaches 0·15 mm. above the level of the aperture of th. 1. Over the first three thecae the thecal count is 13 in 10 mm. and these early thecae are inclined to the axis at a very low angle (5–10°). Both the thecal spacing and angle of inclination of the thecae increases rapidly along the rhabdosome so that at 1 cm. from the base of the sicula they number 9 in 10 mm. and are inclined at 20° to the axis. The overlap at this point is rather less than one-half.

There is no change in the thecal characters distally but the thecae are less closely spaced (7 in 10 mm.) whilst the angle of inclination may be as high as 40°. The thecal overlap is rather more than half and the tubes themselves have a length of 2·5 mm.

Remarks. The species recorded as *M. hisingeri* Carr. var. by Watney and Welch (1911) was probably in part *P. watneyae* for the latter certainly belongs to the *nudus* group of pristiograptids. On the other hand, Watney and Welch record their variety throughout the Wenlock Series, stating that it is rare in their lowest and topmost zones. The writer feels that they have confused pristioform views of *Monoclimacis flumendosae* Gortani 1922 with *P. watneyae* and lumped the two together as *M. hisingeri* Carr. var. *M. flumendosae* is common in their zones of *riccartonensis* and *rigidus* but less common in their highest zone of *lundgreni* (as they record for *M. hisingeri* Carr. var.). *M. flumendosae* is absent in their zone of *murchisoni*, where *P. watneyae* occurs rarely.

The two species *P. watneyae* and *M. flumendosae*, though superficially resembling each other, particularly as regards overall size, are in fact quite distinct. The latter, quite apart from the ventral excavation of the thecal tube, has a characteristic dorsal curvature at the extreme proximal end, a prominent sicula, is more slender, and has a different thecal spacing.

From members of the *dubius* group of pristiograptids *P. watneyae* differs in its slender and slowly widening proximal region. The closest species in the *nudus* group of pristiograptids is *P. nudus* (Lapworth). From this species it differs in the following ways: (*a*) the distal thecae are long rather than broad; (*b*) the rhabdosome is broader distally and more slender proximally; (*c*) the thecal spacing is different; (*d*) the sicula is longer and its apex positioned differently; (*e*) the distal angle of inclination (maximum 40°) is less than in *nudus*.

P. watneyae is more robust than *P. r. regularis* (Törnquist 1899) and *P. r. solidus* (Přibyl 1940*b*).

Pristograptus dubius pseudolatus subsp. nov.

Plate 31, fig. 5; text-fig. 2*k*

Holotype. HUR./18N/53a, specimen well preserved, flattened, proximal end preserved, about 4 cm. long.

Horizon of holotype. Zone of *M. flexilis belophorus.*

Derivation of name. L, to indicate that it is distinct from *P. dubius latus* Bouček 1932.

Material. Thirty-one specimens, proximal and distal fragments, all flattened.

Horizon and localities. Zone of *M. flexilis belophorus* to the basal beds of the Zone of *C. linnarssoni*; Near Gill (16N, 18N, 19N).

Diagnosis. Rhabdosome several centimetres long, proximally with *dubius*-like curvature, but distally quite straight; maximum width 2·7 mm.; thecal tubes simple, inclined to the axis at 20°–30°, numbering 7–10 in 10 mm.

Description. This subspecies is superficially very similar to the type subspecies, but the rhabdosome, whilst showing the same ventral curvature at the proximal end, is distally straight, and broader. A width of 2·0 mm. is reached at only 1·5 cm. from the proximal end, which, at the level of th. 1, is already 0·75 mm. in width. At 3½ cm. the width has increased to 2·34–2·47 mm. and in the most distal fragments seen reaches 2·7 mm.

Initially *P. d. pseudolatus* has the same thecal spacing as *P. d. dubius* (10 in 10 mm.) but at $1\frac{1}{2}$ cm. the count has already fallen to 7 in 10 mm. This latter value is then maintained to the distal extremity.

The angle of inclination ranges between 20° and 30° being usually nearer the lower angle. The sicula is over 2 mm. long, usually 2·3 mm., and its apex reaches to the level of the second thecal aperture.

Remarks. Many of the bedding planes at the locality of the holotype show no signs of compression and this subspecies is clearly not a broad form of *dubius* s.s. resulting from tectonic deformation of the rock. In any case if a specimen of *dubius* s.s. is compressed in such a manner so as to increase the width of the rhabdosome, then the angle of inclination of the thecae and the thecal counts are both increased. In *dubius pseudolatus* the angle of inclination is lower than in *dubius* s.s. and the thecal spacing shows a similar range but is distally less. *P. d. pseudolatus* bears some resemblance to *P. d. latus* Bouček but in the latter the thecae are inclined at a higher angle than *dubius* s.s. (see, for example, Přibyl 1944, pl. 1, fig. 7).

From *P. meneghini giganteus* (Gortani) the Cautley form differs in having a higher thecal count; and from *P. s. sardous* (Gortani) in being rather more slender and in having a lower angle of inclination.

Pristiograptus meneghini meneghini (Gortani)

Plate 29, fig. 7; text-fig. 2*j*

1857 *Graptolithus* (*Monograpsus*) *colonus* Barr?; Meneghini (pars.), p. 164.
1922 *Monograptus meneghini* Gortani, p. 47, pl. 8 (1), figs. 3–8, pl. 12 (5), fig. 6*d*, pl. 13 (6), figs. 2*c*, 4*a*.
1922 *Monograptus meneghini* Gortani, p. 99, pl. 17 (3), fig. 10.
1936 *Monograptus paradubius* Haberfelner, pp. 89–90, figs. 2*a–b*.
1944 *Pristiograptus meneghini meneghini* (Gortani 1922); Přibyl, pp. 11–13, text-fig. 2, figs. E1–3, pl. 1, figs. 1–2.
1952 *Pristiograptus* (*Pristiograptus*) *meneghini meneghini* (Gortani); Münch, p. 86, pl. 18, fig. 9.
1952 *Pristiograptus* (*Pristiograptus*) *meneghini meneghini* (Gortani); Přibyl, pp. 26–27, pl. 1, figs. 4, 15.
?1958 *Pristiograptus* (*Pristiograptus*) cf. *meneghini meneghini* (Gortani 1922); Přibyl, pp. 117–18, pl. 1, fig. 9.
?1962 *Pristiograptus meneghini meneghini* (Gortani); Romariz, p. 283, pl. 13, figs. 13, 16, 17.

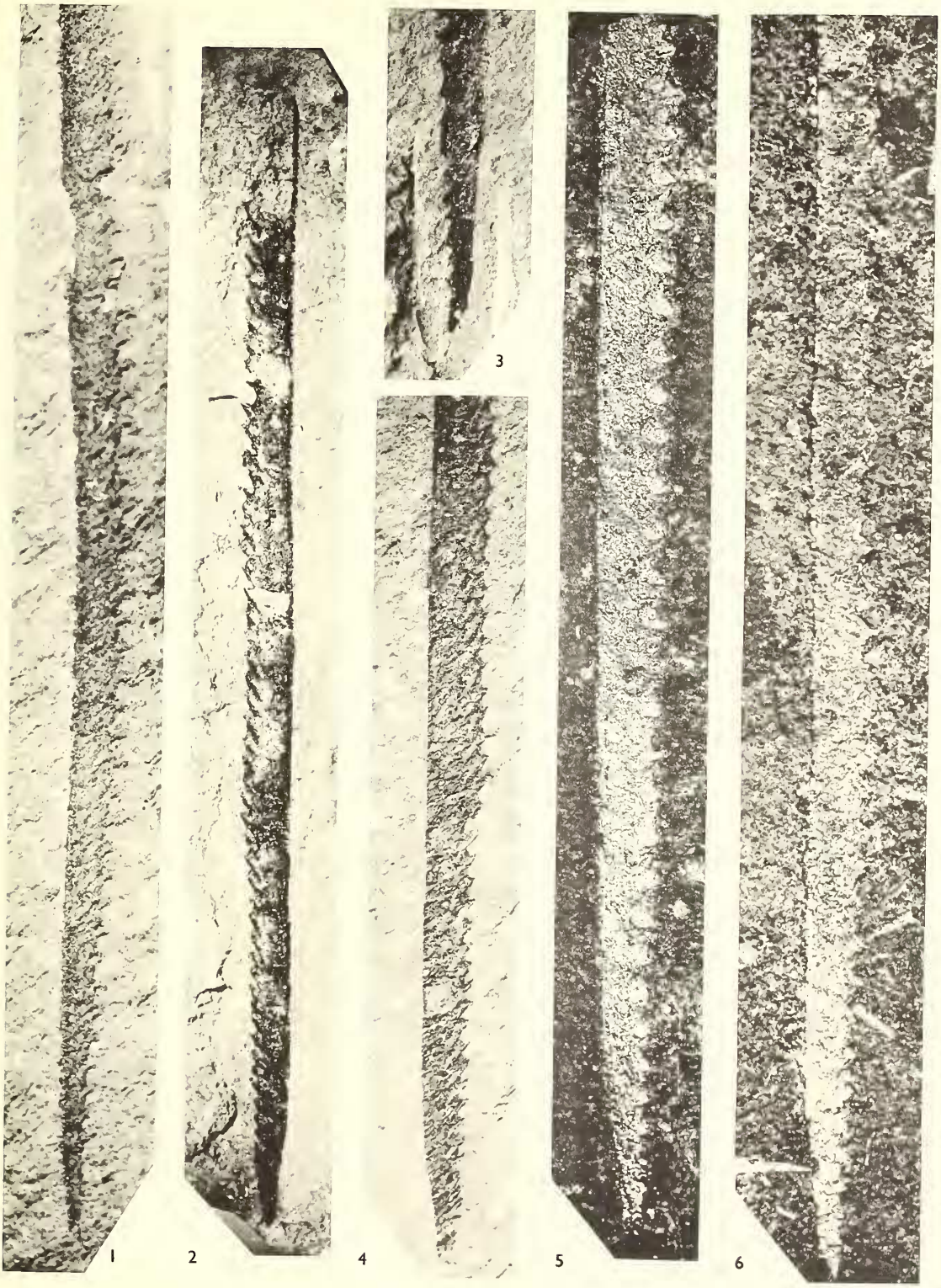
Lectotype. Specimen figured by Gortani (1922), pl. 8 (1), fig. 4.

Material. About eighty specimens, all flattened but well preserved, several proximal ends but distal fragments more common.

Horizon and localities. Zones of *antennularius*, *flexilis belophorus*, and *linnarssoni*; Near Gill (16N, 17N, 20–23N), Middle Gill (16M, 21M, 22M, 25M, 30M), Wandale Hill (68W).

DESCRIPTION OF PLATE 31

Fig. 1, *Monograptus firmus sedberghensis* subsp. nov., holotype, HUR./40W/1 *riccartonensis* Zone. Figs. 2–4, *Pristiograptus auctus* sp. nov. *nilssoni-scanicus* Zone. 2, Paratype, HUR./7W/43. 3, Paratype, HUR./7W/34. 4, Holotype, HUR./7W/46. Fig. 5, *Pristiograptus dubius pseudolatus* subsp. nov., holotype, HUR./18N/53a, *belophorus* Zone. Fig. 6, *P. d. dubius* (Suess), HUR./18N/6, for comparison with *pseudolatus* subsp. nov. All figs. × 5, unretouched.



RICKARDS, Silurian graptolites

Diagnosis. Rhabdosome similar in appearance to, but broader than, *P. pseudodubius* (described below); proximal regions ventrally curved, but distal fragments straight; maximum width 1·6–1·7 mm.; thecal spacing 7–10 in 10 mm.

Description. The rhabdosome is longer than that of *P. pseudodubius* and may reach 5 cm., whilst a width of 1·6–1·7 mm. is reached distally.

The sicula is fully 2 mm. long and its apex extends to about the level of the second thecal aperture. At the level of th. 1 the rhabdosome has a width of 0·65 mm. which increases distally to 1·43–1·50 mm. in most specimens. Some specimens, however, from the zone of *M. antennularius*, are rather broader and reach 1·6–1·7 mm.

The thecal spacing of those specimens from the *antennularius* zone is 7–9 in 10 mm. whilst those from the higher beds have 8–10 in 10 mm. In each case the closer spacing is at the proximal end.

The angle of inclination is approximately 30°.

Remarks. The slight shift in the range of variation of some biocharacters, from the lower to the higher strata, is regarded as a change which would, if continued, give rise to *P. pseudodubius* (Bouček). Those specimens from the zone of *antennularius* are identical with Gortani's original specimens whilst those from the zones of *flexilis belophorus* and *linnarssoni* are slightly narrower and have more closely spaced thecae. *P. pseudodubius* from the *lundgreni* Zone is narrower still and has even more closely spaced thecae.

Pristiograptus pseudodubius (Bouček)

Plate 29, fig. 10; text-fig. 2*i*

1932 *Monograptus pseudodubius* Bouček, pp. 1–2, pl. 2*e–f*.
1944 *Pristiograptus pseudodubius* (Bouček 1932); Přibyl, pp. 8–9, pl. 1, fig. 8, text-fig. I, 3.
1945 *Monograptus pseudodubius* Bouček; Waterlot, pl. 26, fig. 288.
?1962 *Pristiograptus pseudodubius* (Bouček); Romariz, pl. 16, fig. 3.

Lectotype. Specimen figured by Bouček as fig. 2*e* and refigured by Přibyl, text-fig. I, 3.

Material. About thirty specimens, invariably flattened, usually poorly preserved.

Horizon and localities. Zone of *C. lundgreni*; Near Gill (25N–28N), Hobdale Beck (3Bd), River Rawthey (2Ra).

Diagnosis. Rhabdosome short, narrow, with gentle ventral curvature throughout; maximum width 1 mm., thecae number 9½–11 in 10 mm.

Description. The rhabdosome is typically short and slender, appearing gently arched with the thecae on the concave side. Specimens over 2 cm. long have not been observed. Compressed specimens at right angles to the lineation on the bedding plane may reach 1·17 mm. in width; specimens distorted in the opposite sense rather less than 1 mm.

The conspicuous sicula is 1·5 mm. long, with its apex reaching almost to the level of th. 2. A short, stout virgella is present.

Proximally the thecal spacing is rather closer (10–11 in 10 mm.) falling to 9½–10 in 10 mm. mesially and distally. The thecal tubes have a maximum length of 2 mm. and overlap for one-half their length. They are inclined to the axis at 20–30°.

Remarks. In all their diagnostic features the Cautley specimens agree with *P. pseudodubius* (Bouček). The Cautley material is, however, closer in general appearance to other

material figured by Přibyl (1944, pl. 1, fig. 8) than to the original figured by Bouček (1932, fig. 2*e*) and Přibyl (1944, text-fig. I, 3) which appears to be a rather broad variant. Přibyl (op. cit., p. 9) does mention that broad forms occur.

P. pseudodubius has a superficial resemblance to *P. m. meneghini* (Gortani). It differs in being even narrower and in having its thecae more closely spaced. It is considered that *pseudodubius* may have evolved from *meneghini* through forms intermediate in all measurable features but possessing the same general appearance of *P. meneghini*. These species maintain the same order of appearance in Bohemia (Přibyl 1944, p. 44) as in the north of England, but in the latter area *meneghini* first appears at a lower level.

Pristiograptus auctus sp. nov.

Plate 31, figs. 1–3; text-fig. 2*h*

Holotype. HUR./7W/46, almost complete, flattened specimen.

Horizon of holotype. Ludlow Series, *nilssoni* Zone.

Derivation of name. *Auctus*, L. 'increase', 'growth'.

Material. About forty specimens, all flattened.

Horizon and localities. Low in the *nilssoni* Zone; Wandale Hill (7W, 8W).

Diagnosis. Rhabdosome long, broad, and stiff; proximal end with slight ventral curvature, distal parts usually straight; thecae long, simple tubes numbering 11–18 in 10 mm.; sicula long, virgella short and transversely (?) expanded into a disc.

Description. The rhabdosome is about 4 cm. long and usually straight distally, though some specimens show a gentle dorsal curvature. The proximal end is invariably ventrally curved to the extent that six thecae are involved. A maximum width of rather less than 2 mm. is achieved within 2 cm. of the sicula but specimens at right angles to the bedding plane lineation (where present) are often slightly over 2 mm. At the level of th. 1 the rhabdosome is 0·70–0·75 mm. wide.

The sicula is not conspicuous but has a length of 2·3 mm. Its apex reaches to the level of the aperture of th. 3. Thecal spacing over the first few millimetres of the rhabdosome is very close and varies from 17–20 in 10 mm. depending upon the direction of compression. A value of 18 in 10 mm. in the most constant. At a distance of 4–7 mm. from the base of the sicula the thecal count has fallen to 13–18 in 10 mm., 15 being the usual figure, whilst distally 10–14 is the total range encountered.

The thecae are simple tubes which reach a maximum length of 2·5 mm. in the distal region. Here the overlap has increased to three-quarters from two-thirds proximally; and the thecal tubes are inclined to the axis at angles up to 45°.

One of the most striking features of this species is the presence of a short virgella (0·6 mm.) which swells into a bulb-like shape, and has the appearance of a droplet hanging from the proximal end of the rhabdosome (Pl. 31, fig. 3). This swelling is 0·4–0·5 mm. in diameter. Thickening of the virgella in this manner is invariably present, but one specimen, less expanded than the others, suggests the possibility that the virgella is transversely expanded, and that only upon flattening of the rhabdosome does it rotate to the bedding plane. If this is the case, however, rather more specimens with the swelling half buried would be expected.

Remarks. P. auctus is clearly close to such species as *P. vulgaris* (Wood 1900) and *P. tumescens* (Wood 1900). The degree of curvature is intermediate between these two latter species, whilst the breadth of the rhabdosome is nearer *tumescens*. The combination of characters described above serves to distinguish *auctus* from both these species.

Elles and Wood (1910, p. 380) described forms of *tumescens* from the Lake District which are shorter, broader, and have a higher thecal count (12–13 in 10 mm.) than those from the type area. It is possible that these are related to the species here described, although *P. auctus* is longer than *tumescens*, and Watney and Welch (1911) make no mention of any such forms.

Pristiograptus welchae sp. nov.

Plate 30, fig. 6; text-fig. 2*f*

Holotype. Specimen HUR./1Ab/22, and counterpart 22a.

Horizon of holotype. Zone of *M. leintwardinensis*.

Derivation of name. After Miss E. G. Welch.

Horizon and localities. Zones of *nilssoni-scanicus* and *leintwardinensis*; Adamthwaite Bank (1Ab) and Weasdale (1We).

Material. About twenty specimens, all flattened.

Diagnosis. Very small, narrow rhabdosome with only a few thecae developed; length approximately 5 mm.; width (flattened) 0·65 to 0·70 mm.; proximal extremity with slight ventral curvature; sicula 1·2 mm. in length; thecal spacing 14 in 10 mm.

Description. The tiny rhabdosome is most characteristic and unflattened specimens must be of the order of 0·5 mm. wide. Some specimens slightly exceed 5 mm. in length, the holotype being 5·33 mm. The maximum rhabdosomal width is 0·7 mm. and is achieved by the fourth or fifth theca.

The sicula is not prominent but has a length of 1·2 mm. Its apex reaches to the level of the aperture of th. 1. About 6–8 thecae may be present on the rhabdosome and these are all of simple pristiograptid type with a maximum length of 1·3–1·4 mm. and a width of 0·20–0·22 mm. Distally the thecae overlap for one half their length, but rather less than this proximally. The thecae number 14 in 10 mm. throughout the rhabdosome and are inclined to the axis at a low angle—about 20° distally and less proximally.

Remarks. The only species approaching *P. welchae* in dimensions is *P. praeultimus* Münch from the *nilssoni-scanicus* Zone of Thuringia. This is of similar length but rather broader (1·0–1·1 mm.) whilst the thecal spacing is similar. The thecal tubes of *praeultimus* are, however, of *ultimus* type and appear to have a ventral excavation of the thecal margin suggesting that they are not of simple pristiograptid form.

This is a rare species at Cautley and it was not recorded by Watney and Welch (1911) in their work on the Salopian rocks.

Genus MONOGRAPTUS Geinitz 1852

Type species. Lonatoceras priodon Bronn 1835; subsequently designated Bassler 1915.

Diagnosis. Emended here only to exclude *Rastrites* Barrande 1850, *Pristiograptus* Jaekel 1889 and *Monoclimacis* Frech 1897; form of thecae highly variable; many species biform; curvature of rhabdosome highly variable.

Monograptus firmus sedberghensis subsp. nov.

Plate 31, fig. 1; text-fig. 3*a*

Holotype. HUR./40W/1, flattened specimen.

Material. Two well-preserved specimens, other fragmentary specimens.

Horizon and locality. Top of the *M. riccartonensis* Zone; Wandale Hill (40W).

Derivation of name. After the nearby town of Sedbergh.

Diagnosis. Rhabdosome with gentle dorso-ventral curvature, widening from 0·6 mm. to almost 2 mm. at 4 cm. from the sicula; thecae with small hooks numbering 14–15 in 10 mm. over the first few mm. and 12 in 10 mm. distally; overlap one-half, increasing distally.

Description. The rhabdosome is not robust but reaches a maximum width of 2 mm. at about 4 cm. from the proximal end. The total length of the rhabdosome is clearly much longer since almost straight distal fragments are associated with the curved proximal regions. At the proximal end the rhabdosome is characterized by a very striking ventral curvature for a length of about 1 cm. when a change to gentle dorsal curvature occurs which is maintained throughout much of the rhabdosome.

The sicula is small and not prominent. Its length is 1·2 mm. and its apex reaches to about the level of the hook of th. 2. The dorsal margin of the sicula is continuous with the dorsal margin of the rhabdosome, an arrangement which is the prime cause of the slight, but striking, proximal ventral curvature.

The proximal thecae number 14–15 in 10 mm. but become more widely spaced after a few millimetres and remain at 12 in 10 mm. throughout the rest of the rhabdosome.

Thecal overlap increases slightly to rather more than half in the distal portion but the thecae themselves are uniform throughout. There is no apparent change in the nature of the thecal hook which always involves only the top of the thecal tube and closely resembles that of *M. riccartonensis* Lapworth. The distal thecae have a maximum length of approximately 2·5 mm. Throughout the rhabdosome the thecae are inclined to the axis at 30°.

Remarks. The original proximal end of *M. firmus* figured by Bouček (1931b, fig. 5*b*) seems to be a specimen preserved in subdorsal view. Nevertheless the slight ventral curvature of the extreme proximal end can be ascertained, and is sufficient to distinguish the species from *M. riccartonensis* Lapworth and *M. fleningi* Salter. *M. f. sedberghensis* differs from *M. f. firmus* in having a less robust proximal end, a more flexuous rhabdo-

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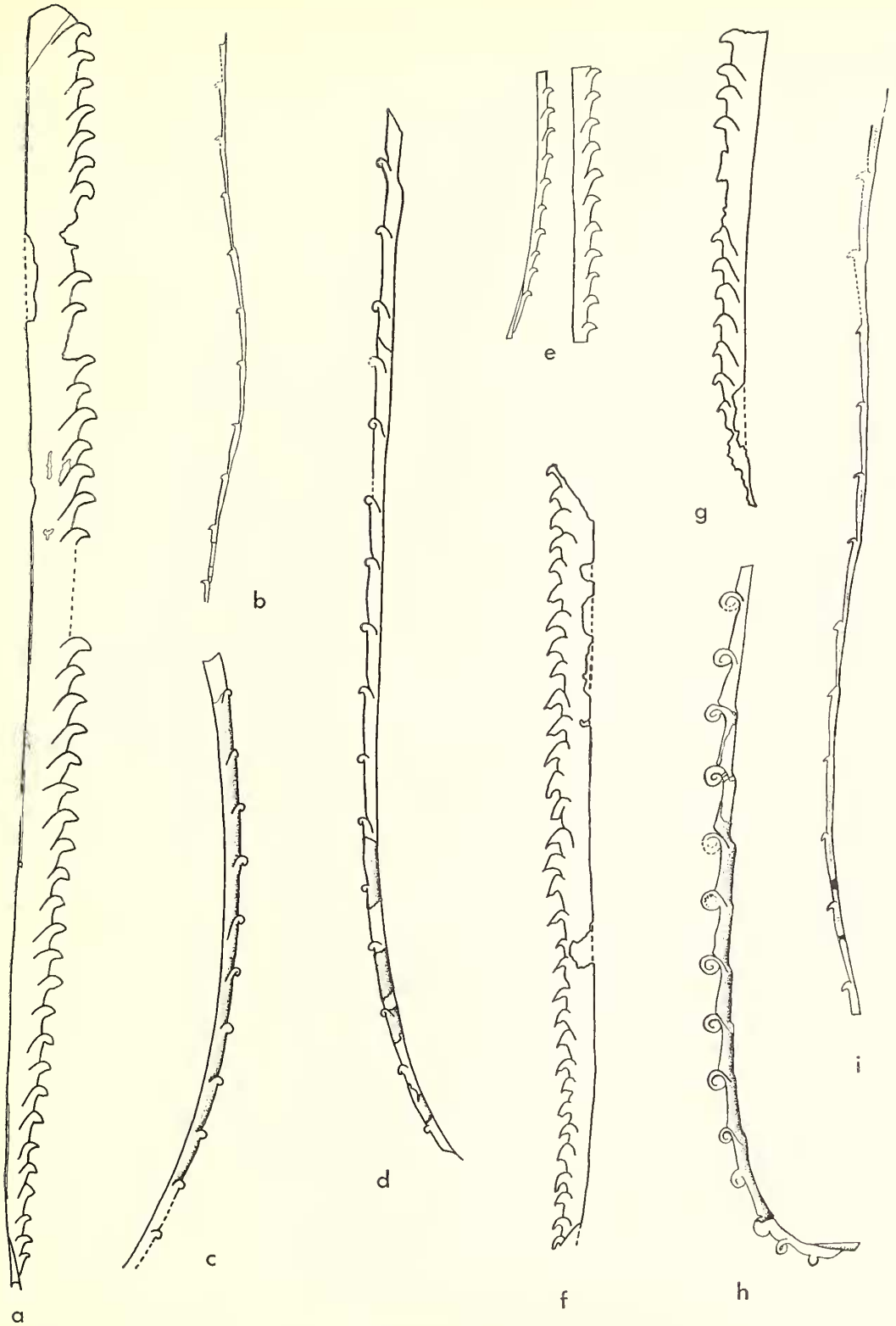
TEXT-FIG. 3. *a*, *Monograptus firmus sedberghensis* subsp. nov., holotype, HUR./40W/1, flattened specimen, *riccartonensis* Zone. *b*, *M. simulatus* sp. nov., paratype HUR./4M/62, preserved in relief, *centrifugus* Zone. *c*, *d*, *M. minimus cautleyensis* subsp. nov., respectively paratype HUR./1M/117 and holotype HUR./1M/50, both in relief, the holotype partly as external mould, *centrifugus* Zone. *e*, *M. radotinensis inclinatus* subsp. nov., proximal end is part of holotype, HUR./39W/3, distal fragment is an adjacent paratype on same slab, *riccartonensis* Zone. *f*, *g*, *M. flexilis belophorus* (Meneghini), HUR./16M/20 and HUR./13M/74, fairly well-preserved specimens showing typical curvature, respectively from *riccartonensis* and *belophorus* Zones. *h*, *M. danbyi* sp. nov. holotype, HUR./8P/1, specimen in full relief, *centrifugus* Zone. *i*, *M. simulatus* sp. nov., holotype, HUR./28W/25, preserved in relief, *centrifugus* Zone. All figures ×5.



TEXT-FIG. 3.

some, and more closely spaced thecae throughout the rhabdosome. *M. f. sedbergheusis* seems to occur at a slightly higher horizon than *M. f. firmus* which is recorded from strata underlying the *riccartonensis* Zone of Bohemia (Bouček 1933).

*M. taricco*i Gortani is a species showing a close resemblance to *M. firmus*. *M. f. sedbergheusis* differs from Gortani's species in being more flexed, more slender, and in the thecal spacing, whilst *M. f. firmus* is shorter, has a more robust proximal region, and has more closely spaced thecae. *M. taricco*i is a Wenlock species but occurs at a higher horizon than *M. f. sedbergheusis* and is associated with *C. rigidus* Tullberg.

Monograptus radotinensis inclinatus subsp. nov.

Text-fig. 3*e*

Holotype. HUR./39W/3, a flattened specimen showing proximal and mesial regions.

Material. Six specimens on a single slab; all flattened but moderately well preserved.

Horizon and locality. Top of zone of *M. riccartonensis*; Wandale Hill (39W).

Derivation of name. *Inclinatus*, L. 'inclined towards'.

Diagnosis. Distal part of rhabdosome like *M. riccartonensis* but more slender; proximal region flexuously curved, dorsal curvature at extreme proximal end; thecae like those of *M. r. radotinensis*; maximum rhabdosomal width 1·2–1·3 mm.; thecae number 9½–11 in 10 mm.

Description. The rhabdosome shows dorsal curvature over the first 2 cm. followed by ventral curvature for a similar length. Distal fragments are more or less straight, fully 8 cm. long, and it seems likely that the total length of the rhabdosome must have exceeded 10 cm. In the specimens obtained the amount of curvature has been lessened by compression. The rhabdosomes are probably close to the original width since although the specimens are compressed in a manner tending to decrease the width, they are also flattened which increases the width.

The sicula is almost 1·7 mm. long and 0·3 mm. wide at the base. Its apex reaches slightly above the level of the hook of th. 1. The proximal thecae number 11 in 10 mm. and are very similar to those of the type subspecies and to those of *M. irfonensis* Elles. They are approximately 1·5 mm. long with a small beak-like hook in the apertural region. Overlap of the thecal tubes is rather less than half.

The distal thecae are more widely spaced (9½ in 10 mm.) and the amount of overlap is about one-half. There is also a slight change in the angle of inclination of the thecae from 10°–15° proximally to 20° distally. The nature of the thecal hook does not appear to change.

Remarks. *M. r. inclinatus* is very similar to the type described by Bouček (1931*b*). It differs from this form, however, in the thecal spacing (9½–11 cf. 9–10), the rhabdosomal width (1·2–1·3 cf. 1·0 mm.), the length (3 cm. cf. 10 cm.) and the curvature. *M. r. radotinensis* has pronounced dorsal curvature at the proximal end whereas *M. r. inclinatus* is flexuously curved, at first dorsally and then ventrally, for a distance which itself exceeds the full length of the rhabdosome of the type subspecies.

M. r. radotinensis was recorded by Bouček (1933) from the zones of *C. murchisoni* and *C. insectus* whilst *M. r. inclinatus* occurs at the top of the *riccartonensis* Zone at Cautley. It seems quite likely, therefore, that the latter has evolved from the type sub-

species by overall increase in rhabdosome size, flexuosity, and spread of the proximal thecal characters further along the rhabdosome. The proximal thecae of both subspecies closely resemble those of *M. irfonensis* Elles (Elles 1900, fig. 19, and Elles and Wood 1912, text-fig. 292) which may have evolved from this stock. If this is the case then *irfonensis* has resulted from further spread of the proximal characters along the rhabdosome to the extent that the *riccartonensis*-like distal parts of *M. radotinensis* are lost.

M. lovisatoi Gortani 1922 has a superficial resemblance to *M. radotinensis* but differs in being more robust and in having widely spaced thecae. The nature of the thecal hook in *lovisatoi* is also rather obscure.

Monograptus simulatus sp. nov.

Plate 29, figs. 4–6; text-figs. 3*b*, *i*

Holotype. HUR./28W/25, long specimen in relief, preserved mainly as an external mould.

Material. Two well-preserved specimens in relief.

Horizon and localities. Zone of *C. centrifugus*; Wandale Hill (28W) and Middle Gill (4M).

Derivation of name. Simulatus, L. 'feigned'.

Diagnosis. Rhabdosome with dorso-ventral curvature, maximum width 0·3 mm., thecae long, narrow, with apertural hook, numbering 5–6 in 10 mm.; overlap nil; sicula unknown.

Description. This rare fossil has a highly characteristic rhabdosome. In the most proximal part known it shows dorsal curvature. More distally the curvature becomes ventral and then once again dorsal. It widens almost imperceptibly from 0·26 mm. to 0·30 mm.

The thecae are widely spaced numbering 6 in 10 mm. proximally and 5 in 10 mm. distally. Throughout most of their length the thecae are closely adpressed to the axis but at their extreme distal end the aperture is involved in a small but prominent hook. As far as can be ascertained the hook is formed quite simply by retroversion of the dorsal lip. The hook occupies about one-third to one-half of the width of the rhabdosome. There is no overlap. The prothecal portion arises as a slender tube approximately 0·07 to 0·09 mm. in diameter, and at this point, because of its delicate nature, often shows a slight crumpling. The protheca widens steadily throughout its length to a maximum of 0·19 mm. immediately prior to the hook itself. Thus the whole prothecal portion takes the form in profile of an axially elongated triangle.

Remarks. The form of the thecae and rhabdosome is so distinctive as to enable separation immediately from other slender monograptids such as *M.* (*Streptograptus*) Yin 1937 and *M.* (*Mediograptus*) Bouček and Přibyl 1948.

A species similar in general form and thecal size is *M. capillaris* (Carruthers) but in this species the hook is more prominent, the rhabdosome wider, and the thecae more closely spaced.

Another similar species is *M. crinitus* which Wood (1900) recorded from the Ludlow Series (*nilssoni* Zone). *M. crinitus* has a similar thecal spacing, thecal hook, and general size, but is rather more robust distally and the protheca lacks the distinctive shape of that of *simulatus*. Nevertheless, the similarity of general form is quite remarkable.